Recommendations for High Quality Field Sampling using the Gel-Push Type S sampler

Prepared for:

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DISCLAIMER:

This document has been prepared to provide guidance on achieving the best quality samples using the GP-S sampler. Following these guidelines does not guarantee that sampling campaigns will be successful, or that any subsequent laboratory testing will be of high quality.

These guidelines do not cover every scenario which may arise during field sampling, and in some cases the supervising engineer will need to deviate from some of the guidelines in this document. Any deviations should be carried out with the goal of maintaining the quality of the sampling procedure. Vibrations and impacts should be avoided.

GENERAL NOTES

Gel-push sampling is a developing technique for obtaining high-quality soil samples suitable for advanced testing in the laboratory (Mori & Sakai, 2016). As the tool continues to be developed, it is likely that some features on the tool will change, and users should be familiar with the operation of the tool prior to attempting soil sampling.

The GP-S sampler is a hydraulically activated fixed piston device. A sketch of the sampler with photos of key components is shown in Figure 1, while diagrams of the sampler at different stages of operation are shown in Figure 2. Hydraulic pressure is applied to the head of the sampler through the drill string which causes the sampling tube and shoe to be advanced downwards into the ground, capturing a soil sample within the plastic sample liner barrel (99 cm long, 76mm OD, 71mm ID).

The GP-S sampler differs from conventional samplers by coating the soil samples with a lubricating polymer gel. The polymer gel is loaded into the sample liner tube, between the "sampling tube advancing piston and the stationary piston. During operation, downward movement of the "sampling tube advancing piston" relative to the stationary piston forces the gel to flow down the annulus between the sample liner tube and the sampling tube before exiting through the fins of the core catcher where it coats the soil sample as it enters the sample liner tube. Excess gel is vented through the top of the tube directly into the borehole. When sampling is successful, the polymer gel enables the soil specimen to slide freely within the sample liner tube. Hence a core catcher is activated at the end of sampling to prevent the soil sample dropping out when the sampler is removed from the borehole.

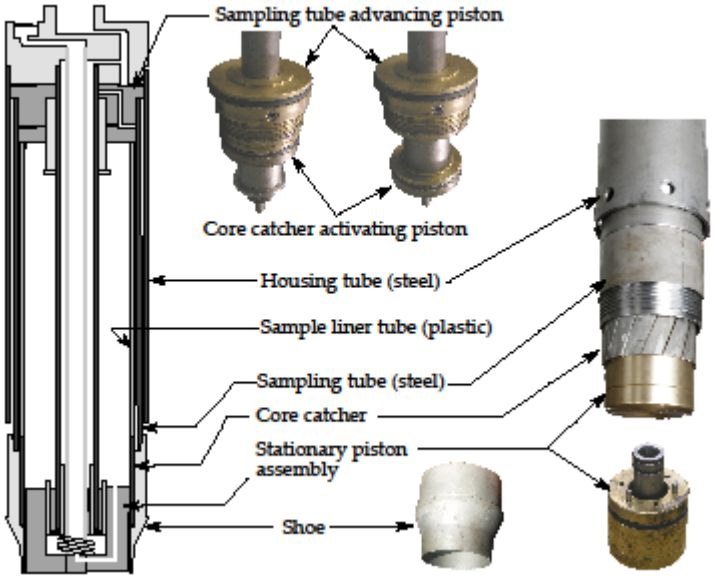

Figure 1: GP-S sampler

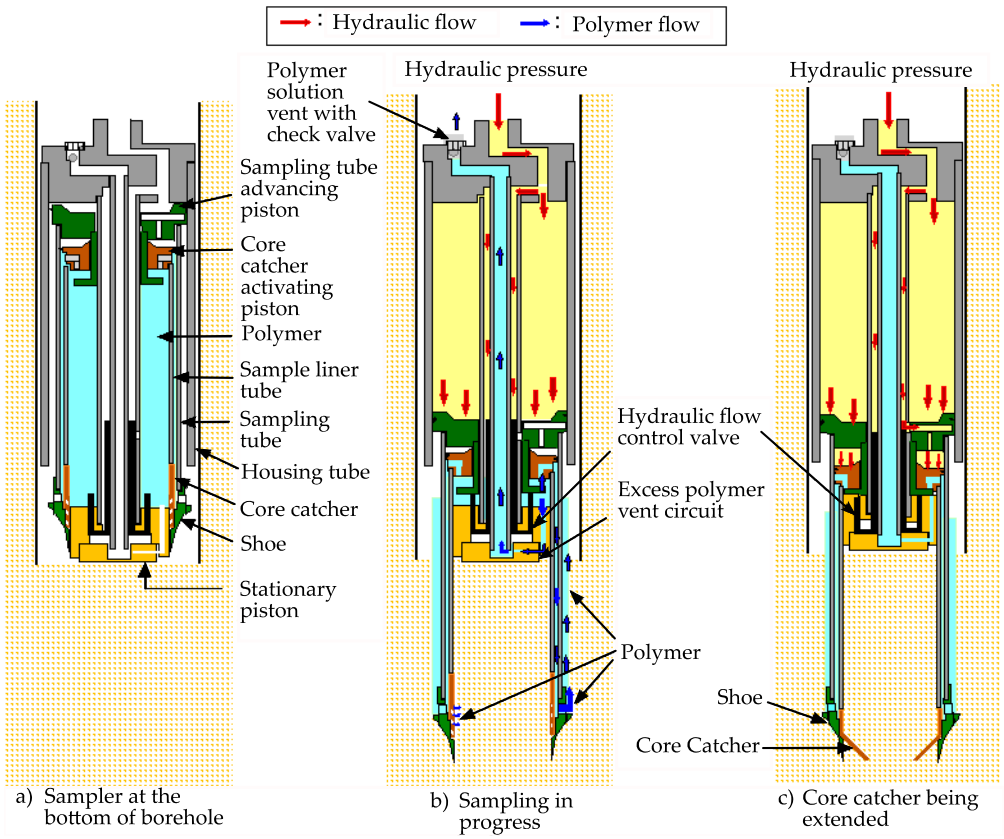

Figure 2: Schematic illustration of GP-S sampler in operation (Mori & Sakai, 2016)

Full recovery with this device yields soil samples which are nominally 70mm in diameter and 925mm in length. With good recovery, it is typically possible to extract up to 5 soil specimens for triaxial testing, assuming that the triaxial specimens are 100mm in length.

Further details concerning the mechanics of the sampler during operation can be found in Mori & Sakai (2016)

The envelope of soil types which can successfully be recovered using the GP-S sampler is still being defined. Previous sampling campaigns in New Zealand reported by Taylor (2014) and Stringer et al. (2015b) as well as internationally (i.e. Huang 2009, Lee et al. 2014, Molina-Gomez et al. 2020) indicate that it is possible to recover high quality specimens of silty sand. It is expected that in the coming years, further research with the tool will define a broader range of soil types where this tool may be used with confidence.

The notes which follow have been prepared for use by engineers and are intended to provide information and guidance at key points to help improve the quality of the sampling operation. These procedures do not explain the detailed assembly or disassembly of the tool. It should be noted that disturbance to soil samples can occur at any point between the start of drilling and the start of testing in the laboratory, and engineers are advised to consider the evaluation of sample quality as an essential part of any testing campaign. This is most commonly assessed as a combination of the visual appearance of the samples and the comparison of in-situ and laboratory estimates of shear wave velocity.

It is important to recognize the significant influence of the post-sampling procedures on the quality of recovered samples, and be aware that high quality samples can be ruined by poor handling. If high quality samples are required, then it is essential that drilling crews are given sufficient time to handle the tool and samples carefully.

OPERATIONAL LIMITATIONS

The GP-S sampler contains a number of thin walled sections which are subjected to high pressures during sampling. To prevent physical damage to the sampler, the hydraulic pressure during sampling should be kept below 6MPa.

Engineers are advised to obtain both a CPT sounding and a logged borehole to understand the stratification at the site of interest and to identify suitable sampling intervals. Engineers are advised not to attempt sampling of soils with cone penetration resistance greater than 5MPa with the GP-S sampler.

Engineers are also advised that sampling soils with gravelly material is likely to damage the cutting shoe of the sampler.

PREPARATION FOR SAMPLING

- Prior to first sampling, the tool should be disassembled to check that the o-ring seals are in good condition and that the pins on the stationary piston moves freely.
- A dry run of the tool should be carried out on the surface, with the cutting shoe removed. During this test, the engineer should check that the tool extends smoothly and that there are no obvious leaks.
- The identifying information and the tube orientation (top/bottom) should be written on the sample liner tube prior to sampling.
- The polymer gel should be mixed to a concentration of 1% by mass.
- After loading the sampler with gel, the plastic sample liner tube should be lifted up and down several times with rotation to fully coat both inner and outer surfaces with the polymer gel.
- Sampling should be carried out from within a cased borehole, with the final casing point set a minimum of two casing diameters and a maximum of 1 m above the intended sampling interval. The section of borehole between the bottom of the casing and the sampling interval should be drilled using a side discharge tri-cone bit after setting the casing. Sufficient mud should be circulated to clear excess cuttings from the hole.
- The depth of the borehole prior to sampling should be checked with a weighted tape.
- The length of drilling rod required to place the bottom of the sampler in contact with the base of the borehole should be measured and marked out. Note the fully prepared sampler is 130.4 cm long.

SAMPLING OPERATION

- **Ensure sufficient reaction force is available to prevent vertical movement of the sampler**. It is recommended to use the rig's top drive for this purpose (See Figure 3).
- Drilling rods should be filled with **clean water** prior to sampling and sampling should be carried out using clean water only. Use a positive displacement pump, **with a maximum pressure of 7MPa.** Sampling should take place at constant rate, with a total sampling time between 1 and 2 minutes. Figure 3 shows a possible configuration to supply fresh water during sampling and

apply the required vertical reaction. In addition to this setup, a pressure gauge and 3-way valve (to vent fluid pressure after sampling) should be attached as close as possible to the top of the drilling rods.

- The total volume pumped during sampling should be monitored. When the sampler is advancing, some polymer gel should be vented through the top of the sampler and may be visible at the top of the borehole. Full sampling requires approximately **6.5 litres** of water provided there are no leaks at the joints of the drilling rods.
- When the sampler has reached full extension, the "core catcher activating piston" closes the core catcher to prevent sample drop out. This is usually associated with a drop in the pump pressure. Sampling is considered complete when at least 6.5 litres of water has been pumped and a significant pressure rise is observed. In cases where stiffer soils are being sampled, high pressures might be necessary throughout sampling. In this situation, it will not be possible to observe a signature rise in pressure and the end of sampling must be judged on the total volume of water pumped.
- When sampling has been completed, the constant pressure pump should be turned off and the fluid pressure vented.

Figure 3: Adapter to supply fresh water for GP-S sampling

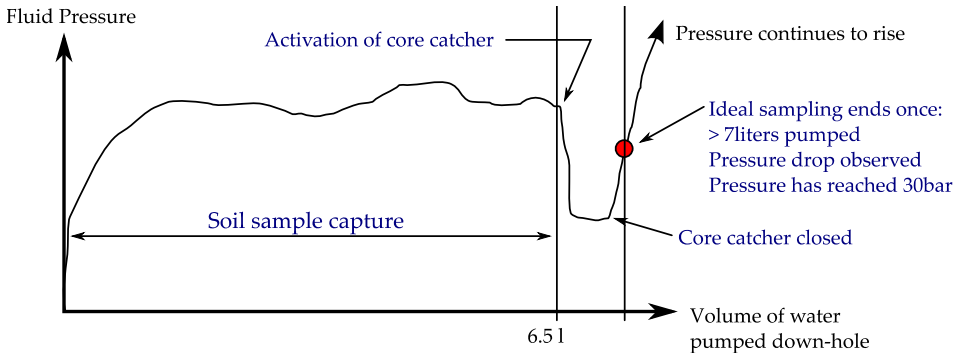

Figure 4: Idealised pressure-flow profile for GP-S Sampling

AFTER SAMPLING

- Leave the sampler for at least 10 minutes prior to pulling the sampler to the ground surface.
- When pulling the sampler, the first meter should be lifted slowly to avoid large vacuums as the sampler is retrieved from the hole.
- Maintain the fluid level in the borehole as the sampler is withdrawn.
- The end of the sampler should be covered as the sampler is lifted out of the drilling fluid to prevent the sample dropping out.
- When breaking drill rod connections, care should be taken to minimise any shock loads on the sampler. i.e. gradually apply break out arms and gently attach the wrenches.
- Remove as much of the drill string as possible prior to lifting the sampler clear of the hole.
- The tool should be laid out horizontally as gently as possible so that the sample can be released from the tool.
- Before removing the cutting shoe, use a thin blade (i.e. a pallet knife) to separate the soil from the core catcher.
- When removing the sample barrel from the fixed piston sampler, the soil within the tube should be held in a fixed location using a cylindrical block (which can fit inside the sample barrel) and the sample barrel slid back off the piston (Figure 5).

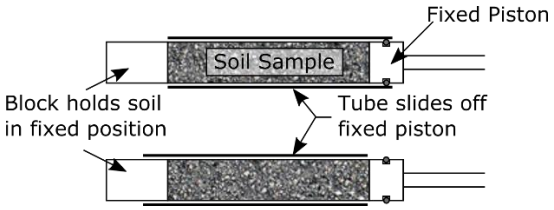

Figure 5: Removing sample barrel

- Measure the length of the sample retained in the barrel.
- The sample should be allowed to drain in the vertical position and with the bottom of the soil sample in contact with a cloth for a minimum of 2 hours prior to transportation.
- After sampling is completed, the tool should be completely broken down (disassembled) and cleaned with fresh water. O-rings should be inspected for any signs of deterioration. Pipe dope should be applied to threaded sections.

SAMPLING RECORDS

It is recommended that as a minimum, the following items are recorded by the supervising engineer:

- Date and time of sampling.
- Location, borehole ID and sampling interval.
- Depth of the top of the sample relative to ground surface.
- Depth of the bottom of the casing string relative to the ground surface.
- Maximum pressure during sampling and total volume of water pumped.
- Time required to advance sampler.
- Whether the core catcher was properly activated at the end of sampling.

- Length and appearance of sample, including whether the sample slides freely in the tube at the surface.
- Any abnormalities during sampling.

TRANSPORTATION

- Engineers should attempt to reduce the vibrations and shocks experienced by the samples during transport. This may include placing the samples on a car seat, and wrapping the samples in foam or rags.
- Where possible, samples should be transported in a vertical orientation.

LABORATORY TESTING

- Any laboratory testing on the soil samples should take place as soon as possible after sampling.
- In preparation for testing, soil samples should be extruded vertically and cut into shorter specimens using a wire saw. Engineers should note that both the drilling operation immediately prior to sampling and the final closure of the core catcher are likely to disturb the soil at the extreme ends of the sample. It is recommended that the top 10cm and bottom 5cm (in addition to any material retained in the core catcher) of the soil sample be discarded.
- Soil specimens should be trimmed in a soil lathe using a sharp knife to remove soil which has become impregnated with the polymer gel (usually 2-3mm). In coarser soil specimens (i.e. sands), polymer gel can impregnate the entire specimen and these specimens must therefore be tested with some gel remaining in the soil. It is expected that research will be carried out in the coming years to investigate the effect which polymer gel may have on test results.

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